INTERCONNECTION INNOVATION e-XCHANGE
U.S. DEPARTMENT OF ENERGY

Sneak Peek: A Roadmap to the Future of Interconnection Innovation

An initiative spearheaded by the Solar Energy Technologies Office and the Wind Energy Technologies Office

8:00 am– 12:00 pm | September 11th, 2023
RE+ 2023

i2x@ee.doe.gov | energy.gov/i2x

1. Welcome & Opening Remarks
2. FERC Order 2023 Highlights
3. i2X Solution e-Xchanges Takeaways
4. Roadmap Overview & Solution Concept Interactive Exercise
5. Closing & Networking

Solar Energy Technologies Office (SETO) Overview

MISSION

We accelerate the **advancement** and **deployment of solar technology** in support of an **equitable** transition to a **decarbonized economy no later than 2050**, starting with a decarbonized power sector by 2035.

WHAT WE DO

Drive innovation in technology and soft cost reduction to make solar **affordable** and **accessible** for all Americans

Enable solar to support the **reliability**, **resilience**, and **security** of the grid

Support **job growth**, **manufacturing**, and the **circular economy** in a wide range of applications

Why interconnection and why now?

From **40 MW/day** of new PV *to* **80-160MW/day** *within 12* years
needs **2x/4x** faster **Interconnection procedures**

Zero-Carbon Future

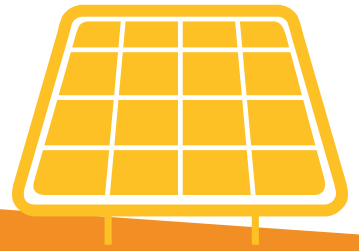
Irreversible path to zero-carbon electricity system by 2035 is contingent on paradigm-shifts in interconnection practices to deploy clean energy technologies at exponential scales

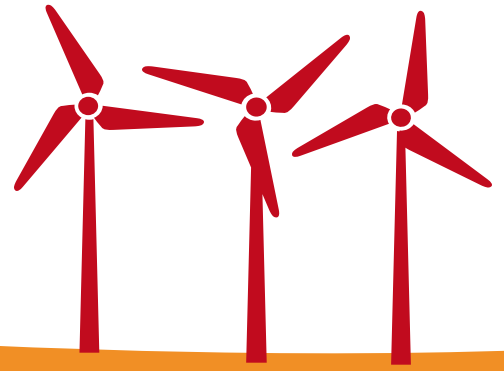
Complexity

The modern grid is transforming rapidly, and grid Interconnection processes are growing ever more complex as penetrations levels increase and technologies advance

Equity

Inclusive and just transition. Broad group of stakeholders required to fully understand the regulatory, technical, and process challenges in interconnection





5x **Increase in the expected number of solar & wind deployments every year to meet 2035 targets**

* Adapting Solar Futures Study findings of average +30GW/year (2020-2025) and +60GW/year (2025-2035) for solar

i2X Key Elements

Mission: To enable a **simpler**, **faster**, and **fairer** interconnection of clean energy resources all while enhancing the **reliability**, **resiliency**, and **security** of our electric grid.

Stakeholder Engagement

Nation-wide engagement platform and collaborative working groups

Data & Analytics

Collect and analyze interconnection data to inform solutions development

Strategic Roadmap

Create roadmap to inform interconnection process improvements

Technical Assistance

Leverage DOE laboratory expertise to support stakeholder roadmap implementation

energy.gov/i2x

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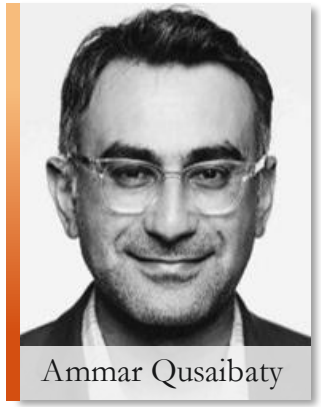
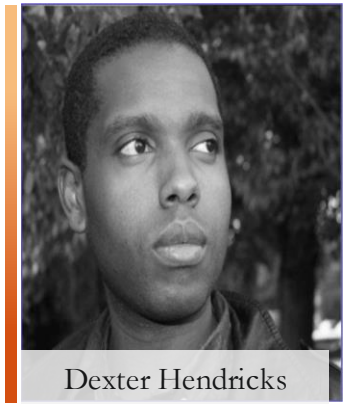
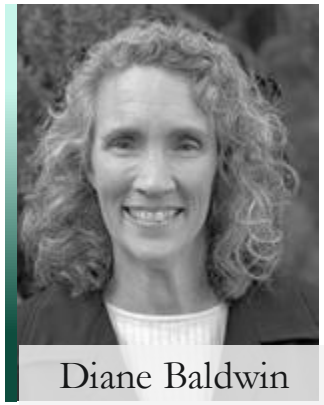
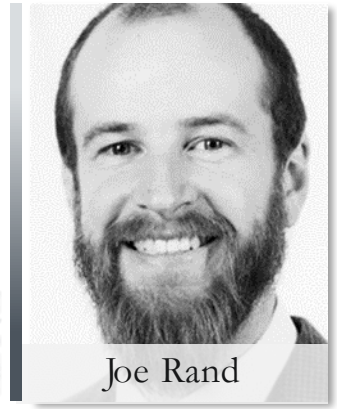
i2X Leadership Team

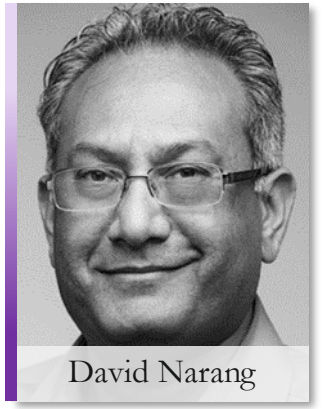

SETO
Ammar Qusaibaty

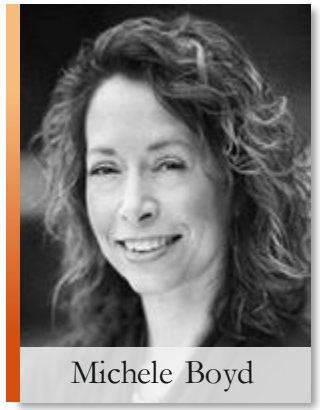

WETO
Cindy Bothwell


SETO
Dexter Hendricks

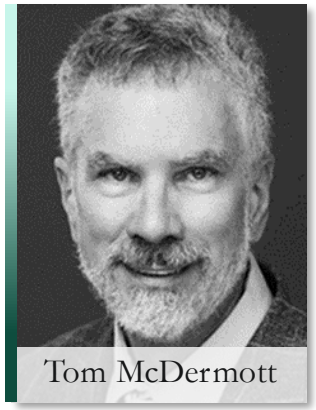

PNNL
Diane Baldwin

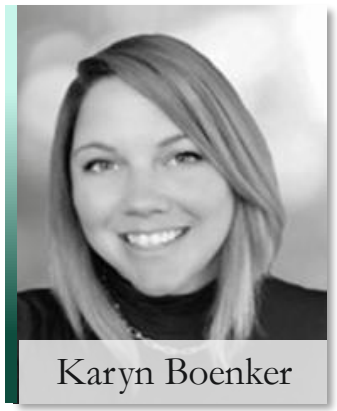

LBNL
Joe Rand


NREL
David Narang


SETO
Michele Boyd


WETO
Jian Fu


PNNL
Tom McDermott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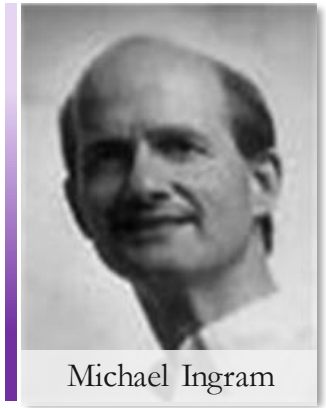
Karyn Boenker


LBNL
Will Gorman


NREL
Michael Ingram

i2X Activity Highlights

Stakeholder Engagement

- 740+ people at 530+ partner organizations joined i2X
- 18+ public events and engagements
- 22 Solution e-Xchange meetings covering 6 topics organized and convened
- 75+ Office-Hour Calls with stakeholders
- Open Social platform for stakeholder engagement (under development)

Data & Analytics

- BPS interconnection cost reports for MISO, PJM, NYISO, SPP, and ISO-NE, plus a summary published (LBNL)
- 2023 Queued Up report updates published on BPS interconnection timelines (LBNL)

Strategic Roadmap

- Will soon release Volume 1 of the draft Roadmap through a request for information (RFI) asking for stakeholder comments and feedback.

Technical Assistance

- Technical assistance projects covering flexible interconnection, utility data management, streamlining interconnection modeling, and alternatives to costly grid network upgrades
- Workforce upskilling with i2X/NERC bootcamps for BPS grid engineers on using Electromagnetic Transient (EMT) modeling methods and techniques

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Presenter

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Highlights of FERC Order 2023

Ammar Qusaibaty | RE+ 2023
Solar Energy Technologies Office

Disclaimer: The views and opinions expressed in this presentation are those of the speaker and do not necessarily represent or reflect the official position of the U.S. Department of Energy.

Disclaimer

On July 28th, 2023, the Federal Energy Regulatory Commission (FERC) issued Order No. 2023, its final rule on “Improvements to Generator Interconnection Procedures and Agreements.”

The information contained herein reflects the presenter's understanding of the Order's details and does not represent the official position of the U.S. Department of Energy or FERC. Neither the U.S. Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or use of information presented here. **Please consult with your legal counsel or contact FERC for any clarifications or questions.**

The order is available on FERC’s website. (Docket No.RM22-14-000)

FERC reforms interconnection procedures and agreements

184 FERC ¶ 61,054
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

18 CFR Part 35

[Docket No. RM22-14-000; Order No. 2023]

Improvements to Generator Interconnection Procedures and Agreements

(Issued July 28, 2023)

AGENCY: Federal Energy Regulatory Commission.

ACTION: Final rule.

SUMMARY: The Federal Energy Regulatory Commission (Commission or FERC) is adopting reforms to its *pro forma* Large Generator Interconnection Procedures, *pro forma* Small Generator Interconnection Procedures, *pro forma* Large Generator Interconnection Agreement, and *pro forma* Small Generator Interconnection Agreement to address interconnection queue backlogs, improve certainty, and prevent undue discrimination for new technologies. The reforms are intended to ensure that the generator interconnection process is just, reasonable, and not unduly discriminatory or preferential.

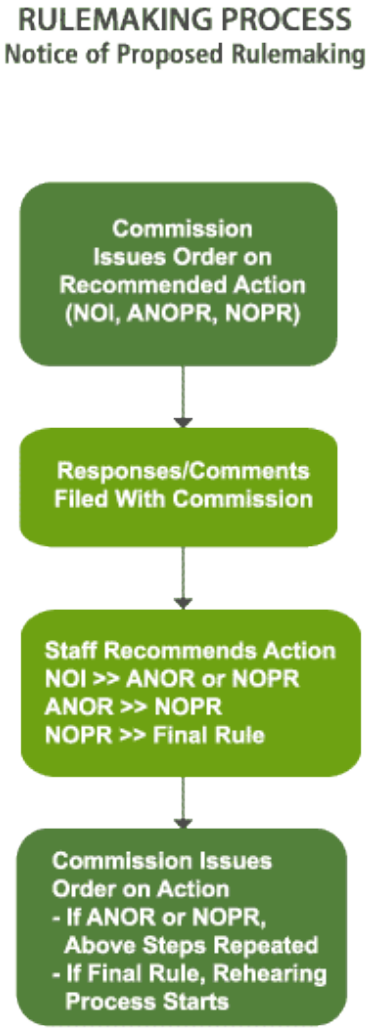
FERC Chair Willie Phillips at his press conference on July 27, 2023, after the commission unanimously approved Order 2023. **Source**: FERC's YouTube Channel

Agenda

- About the Order & Basic Terms
- Areas that the Order covers
- Highlights
  - Heatmaps
  - Overall process and associated costs
  - Penalties
  - New affected systems process
  - Technological innovation
- Discission

About the Order

- FERC authority under Sec. 205, 206 of Federal Power Act
- Historical framework: Orders 2003, 2006, 845 (2019)
- Rulemaking process timeline
  - Advance Notice of Proposed Rulemaking (ANOPR) on 07/15/2021, for improvements to regional transmission planning and cost allocation and generator interconnection processes
  - NOPR on 07/5/2022 for improvements to generator interconnection procedures and agreements
  - Public comments period ended 11/13/2022. FERC staff reply to comments 12/14/2022.
  - Final order released on 07/23/2023
- Reforms to orders 2003 (LGIP LGIA) 2006 (SGIP SGIA)
- All four FERC Commissioners supported the final rule



Order addressed many issues

- Information Study
- Heatmaps
- Cluster Studies
- Cluster Study Costs
- Co-located Generating Facilities
- Storage Operating Assumptions
- Shared Network Upgrades
- Study Deposits
- Site Control
- Commercial Readiness
- Generating Facility Additions
- Alternative Technologies
- Withdrawal Penalties
- Reasonable Efforts/Penalties
- Affected Systems Coordination
- Optional Resource Solicitation Study
- Surplus Service Requests
- Modeling and Ride Through for Nonsynchronous Generators

Basics terms

- "Just", "reasonable", and not "unduly discriminatory" or "preferential" are key principles in section 205 of the Federal Power Act and its amendments (e.g., EP Act 2005)
- Small generating facility (20 MW or less). Large generating facility (>20 MW).
- *Pro forma* Large Generator Interconnection Procedures (LGIP). Similarly, SGIP.
- *Pro forma* Large Generator Interconnection Agreement (LGIA). Similarly, SGIA.
- Transmission provider refers to Independent System Operators/Regional Transmission Organizations (ISO/RTO) and Non-ISO/RTOs utilities, unless otherwise stated.
- Transmission provider' *tariff.*
- Affected system (AF), AF interconnection customer, AF host, AF operator
- Network Resource Interconnection Service (**NRIS**). Energy Resource Interconnection Service (**ERIS**)
- Compliance standards subject to regional difference and entity independence variation
  - Non-RTO/ISOs obligated to demonstrate "a consistent with or superior to" compliance

Implementing a "first-ready, first-served" cluster study process

- **Facilitating Interconnection Information Access:**
  - "Interconnection Feasibility Study" process is replaced with a new data access requirement (Heatmaps)
  - Transmission providers (TP) must maintain a publicly accessible visual representation of available transmission capacity (Heatmaps).
  - Heatmaps publicly availability required after the transition period.
- **Cluster Studies:**
  - "Interconnection System Impact study" process is replaced with a "Cluster Study".
  - Cluster study include stability analysis, power flow analysis, and short circuit analysis for qualified generators with signed cluster study agreements
  - More stringent site control and commercial readiness conditions
  - Cluster study agreements entail escalating financial commitments and penalties for withdrawing during study or after.

Heatmaps

- Heatmap to be updated within 30 calendar days after the completion of each cluster study and cluster restudy
- Interactive output based on input in each point of interconnection (POI):
  - (1) the distribution factor. (2) the MW impact
  - (3) % impact per Impacted transmission facility (ITF)
  - (4) % power flow per ITF before the proposed project. (5) % power flow per ITF after the injection of the proposed project."
- Calculate under N-1 conditions using the power flow model of the whole system.
- Simulate transfers from each interconnection point across the entire provider's footprint. Adjust for existing and queued generation at each location based on interconnection service limits
- A GIS map is not a requirement. It's up to TP to decide how to provide the information

Process Overview

- Single 45-day cluster request window
- 60-day customer engagement window
- Multi-step study process
  - Cluster Study
  - Cluster restudy
  - Facilities Study
  - Ongoing demonstrations of commercial readiness and withdrawal penalties
- Results of study reflected in heat maps.

Overview of process by counting days

- TP gives a **180-day advance notice** to open cluster request window.
- TP offers at least one annual cluster study opportunity. Different cluster studies can overlap
- TP opens **"cluster request window" for 45 calendar days**. Cure period within 10 days before closing
- Within 5 business days window close, TP sends **cluster study agreement** to each interconnection customer (IC)
- Within 10 business days window close, TP post on OASIS **list of Interconnection Requests** (anonymous)
- The **60-day customer engagement window**. ICs engaged as a group. Sign cluster study agreement.
- **150-day cluster study**.
- **150-day cluster restudy** (if triggered).
- **60-day** Interconnection Agreement **negotiation window**
- The **90- or 180-day facilities** study
- The **150-day affected system study** (if triggered)*
- Ongoing demonstrations of commercial readiness and withdrawal penalties throughout studies
- Results of study reflected in heat maps.

How fast can it go?

- Minimum number of days for the whole process is 245 days (no cluster restudy, no interconnection agreement negotiation, “less accurate” facilities study and no affected systems study).
- It can be up to 800 days and possibly more.
  - 45 calendar day “cluster request window”,
  - 60 day “customer engagement window”,
  - 150-day cluster study and a possible 150-day cluster restudy,
  - 60-day interconnection agreement negotiation
  - 90-day to 180-day facilities study depending on accuracy required
  - 150 affected system study, if triggered, it can be done in parallel

Reasonable Efforts and Penalties

- FERC abandoned the 'reasonable efforts' standard in favor of binding study deadlines with penalties for noncompliance.

Cluster Study	Cluster Restudy	Affected System Study	Facilities Study
$1,000/business day	$2000/business day	$2000/business day	$2,500/business day

- Penalties are capped at 100% of applicable study deposit(s)
- Penalties are distributed to participants in the delayed cluster
- Cannot be recovered through rates

Exceptions and Relief

- 10 business day grace period
- Can be extended up to 30 days by mutual agreement of cluster participants
- Penalty provisions do not apply until third cluster cycle
- Penalties can be appealed for “good cause”

How much it costs to apply?

- A non-refundable $5,000 application fee
- Deposits
  - The study deposit
  - Commercial readiness equal 2x study deposit
- In lieu of 90% site control evidence deposit of $10,000 /MW (Min $500k. Max $2m)

Size of Proposed Generating Facility	Study Deposit
>20 MW < 80 MW	$35,000 + $1,000/MW
≥ 80 MW < 200 MW	$150,000
≥ 200 MW	$250,000

In lieu option is highly restrictive and applies in only few scenarios

Important details/models to include in IR

- A proposed point of Interconnection
- Generating Facility Capacity (MW)
- NRIS vs. ERIS
- Generator with electric storage or other export control technology
  - (1) the requested operating assumptions
  - (2) a description of **any control technologies** (software and/or hardware)
- Inverter based generators need to submit
  - A list of models for the plant facility and all of its controls (e.g., RMS)
  - A validated electromagnetic transient model (EMT) model **if the transmission provider performs an EMT study** as part of the interconnection study process.

Cluster Study Cost Allocation

Study Costs

- TP can allocate between 10% and 50% of cluster study costs on a per interconnection request basis with remaining 50%-90% allocated pro rata on a per MW basis

Network Upgrade Costs

- Network upgrade costs are allocated based on a 'proportional impact' method.
- Shared upgrades at substations will be allocated based on the number interconnection requests connecting to the substation
- Customers can have agreements to share costs when sharing interconnection facilities

Shared Network Upgrades

- Allocating network upgrade costs between earlier and later clusters not allowed.

Financial Commitments and Commercial Readiness

Site Control

- 90% of the land necessary for generating facility when submitting request.
- 100% of land at time of execution of a facilities study agreement and at execution of a Large Generator Interconnection Agreement (LGIA)
- Deposits in lieu of site control allowed only where there are preventive regulatory restrictions to site control
  - $10,000/MW
  - Must demonstrate 100% site control within 180 days of the effective date of the LGIA
- Must have 'exclusive' land right to develop, construct and operate.

Financial Commitments and Commercial Readiness (cont'd)

Commercial Readiness

- A commercial readiness deposit is required prior to each study
  - Readiness deposit of twice the study deposit when entering the initial cluster study
  - Remaining readiness deposits are based on network upgrade costs:
    - 5% of network upgrade costs when entering restudy
    - 10% when entering facilities study
    - 20% upon execution of LGIA

Withdrawal Penalties

- Interconnection Customers will face increasing penalties for withdrawal based on study costs or Network Upgrade estimated costs depending on time of withdrawal
  - Included exceptions such as for increased costs (25% threshold)

Affected System Studies

Order 2023 adopted a new, standardized affected system study process and agreements including notification, standardized study process, queue priority for network upgrade cost allocation, presentation and assessment of results and penalties for missed deadlines.

Queue Priority & Studies

- Affected system customers are assigned priority queue positions based on the date of execution of the affected system study agreement.
  - Queue position is used to determine cost allocation for affected system customers.
- Requires affected system customers to be studied through cluster studies.
  - Results within 150 calendar days after execution of study agreement.

Reimbursement

- Affected systems transmission providers are required to reimburse affected system interconnection customers for the costs of affected systems of Network Upgrades.

Modeling Standards

- The final rule requires that all affected system studies be conducted using Energy Resource Interconnection Service (ERIS) modeling standards.

More Flexibility

Co-located Resources

- Allow more than one generating facility to interconnection at the same POI. Agreements needed where different interconnection customers involved when applying

Generating Facility Additions

- Additions (e.g. storage) cannot trigger material modifications by default, if:
  - The addition is submitted before submitting the executed facilities study agreement
  - The existing interconnection service level remains unchanged

Surplus Interconnection Service

- Interconnection customers are allowed to access surplus service once the original interconnection customer has executed the LGIA or requested the filing of an unexecuted LGIA.

Incorporating Operating Assumptions for Storage Resources

- To use operating assumptions that reflect the proposed charging behavior of electric storage resources (whether standalone, co-located, or hybrid)

Alternative Transmission Technologies (ATT)

Alternative transmission technologies to be evaluated regardless of customers requests:

- Static synchronous compensators
- Static VAR compensators
- Advanced power flow control devices
- Transmission Switching
- Synchronous condensers
- Voltage Conductors
- Tower lifting

Transmission Provider has ”Sole discretion" whether ATT should be adopted in a particular case.

Transition Process

- Customers in queue upon implementation of the cluster process have three options:
  - Withdrawal from the queue without penalty
  - Transitional serial study for customers with a tendered Facilities Study agreement
  - Transitional cluster study
- Transmission providers with cluster studies, or transition plans, in progress do not need a new transition process.

Compliance Procedures

- Effective 60 days after publication in the Federal Register
- 90-day period for Compliance filing.
- FERC evaluates compliance filing according to
  - “Independent entity variation” standard for ISO/RTO
  - “Consistent with or superior to' and regional difference standards for Non-RTO/ISO

Notable comments

Commissioner Clements "*encourage(d) transmission providers, interconnection customers, and other stakeholders to view the rule's requirements as a strong baseline and not a ceiling*". She also stated that "*a comprehensive solution set will require out-of-the-box thinking in some areas and continued incremental improvements in others*."

She outlined the following:

1. Deep Reforms
   - Link the interconnection process to proactive transmission system planning
   - Align interconnection processes with competitive resource solicitations
   - Facilitate a "focused" interconnection process
2. General Interconnection Process Improvements
   - Further refine study assumptions
   - Reduce delay and cost overruns in network upgrade construction
   - Use automation to facilitate more efficient interconnection
   - Address challenges faced by projects serving Tribes and Tribal communities

Commissioner Allison Clements

Join . Engage . Collaborate

Discussion

Website: energy.gov/i2X
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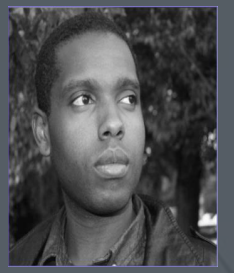

Presenter

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Solutions e-Xchange Summary

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Intro to i2X Solution e-Xchanges

- **FY23 Goal:** Inform and formulate a 5-Year Strategic Roadmap for interconnection & study guides with real world action
  - Topical challenges and issues
  - Practical solutions to implement and scale
  - Knowledge gaps and new solutions to pilot
  - Success goals and measures of success
- **FY23 Schedule:** Solution e-Xchanges held for 2hrs on Wednesdays and/or Thursdays during April - August.
  - Queue Management and Cost Allocation for both BPS and DER most extensive number of meetings due to popular demand
  - Four other topics (e.g. EEJ, Data Transparency, Workforce)
  - Options for specialized topic meetings (e.g. EV Grid Assist/Vehicle Grid Integration)
- **Beyond FY23 :** Solution e-Xchanges to continue building a national forum for all stakeholders as a community of practice, excellence and innovation (Ideation. Solution-driven Collaboration. Peer-Learning.)

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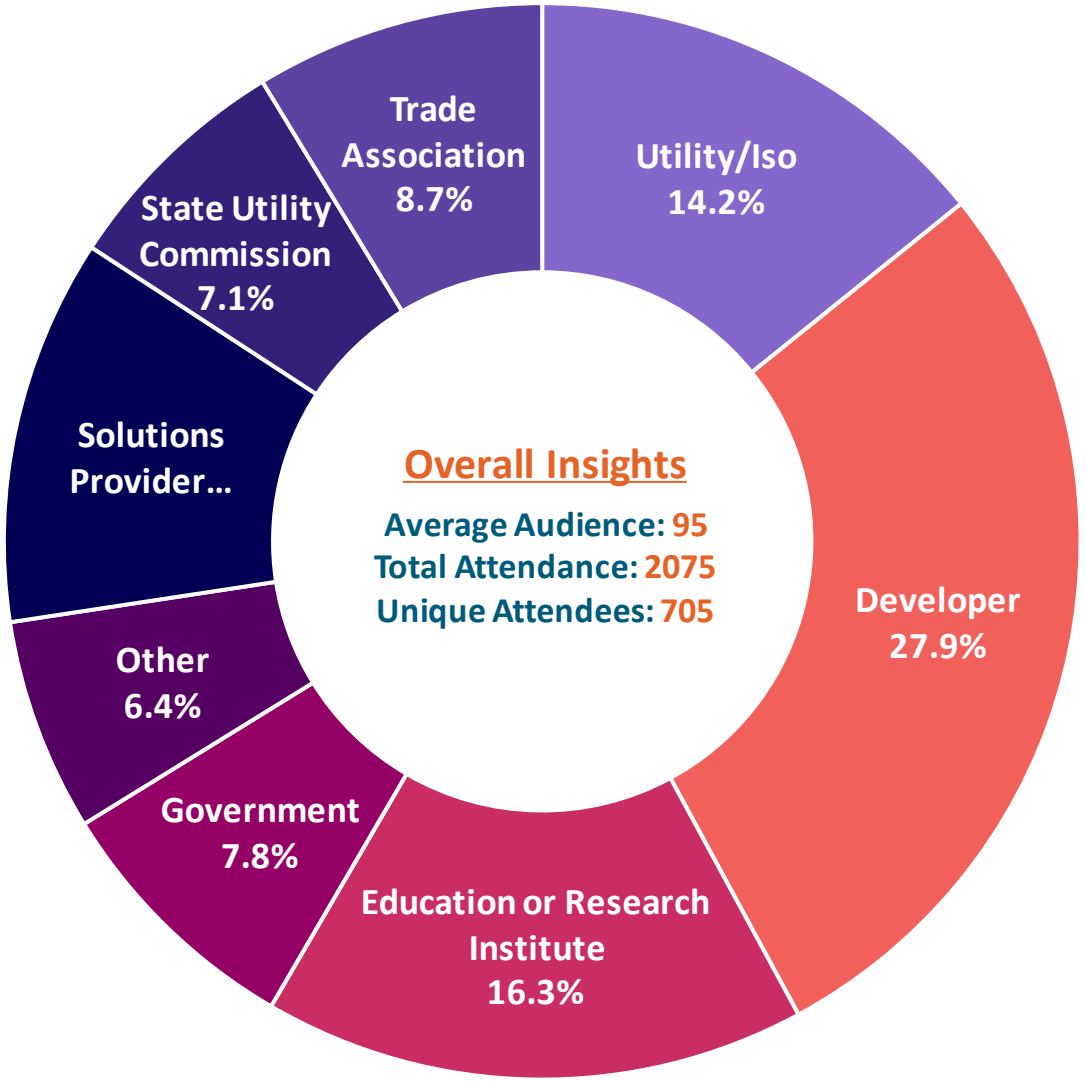
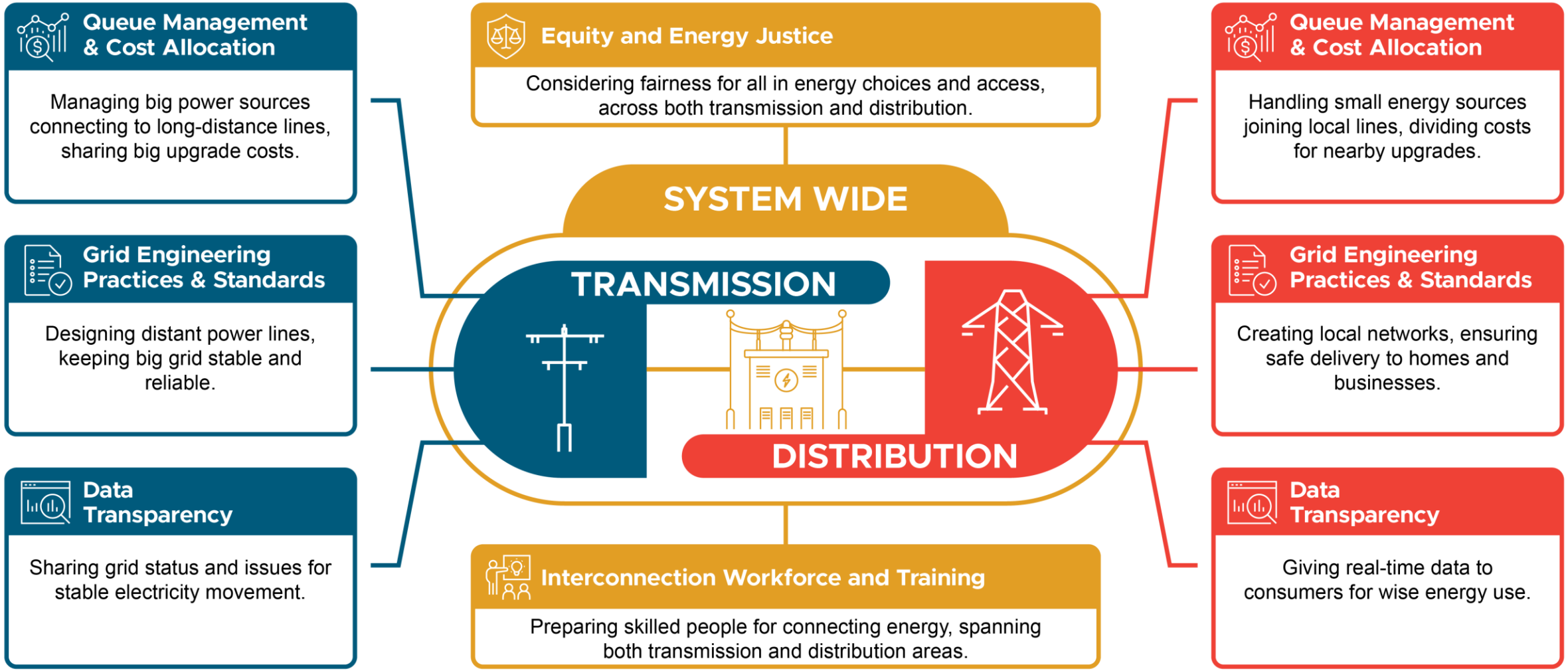
i2X Solution e-Xchange Attendance

Queue Management and Cost Allocation			
Meetings (including kick-off)	9	Avg Attendance	127
Grid Engineering Practices and Standards			
Meetings	3	Avg Attendance	96
Equity and Energy Justice			
Meetings	2	Avg Attendance	53
Data Transparency			
Meetings	2	Avg Attendance	104
Interconnection Workforce and Training			
Meetings	4	Avg Attendance	55
EV Grid Assist/Vehicle Grid Integration			
Meetings	2	Avg Attendance	56



Additional subjects, like capacity maps, cross these topics and will be addressed from these different perspectives. Follow the schedule of events on the i2X website.

i2X Solution e-Xchange Topic Areas



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i2X Solution e-Xchange Topic Areas

Queue Management & Cost Allocation

Queue Management and Cost Allocation

Queue Management | Bulk Electric System

Solutions e-Xchangers share their frustrations:

- Interconnection queues filled with **record number of projects** and **capacity**
- Lengthy **backlogs**, study **timelines**, and **cost uncertainty** for interconnection customers
- **Few projects are actually built**

Queue Management and Cost Allocation

Suggested Reforms:

- More stringent but reasonable **readiness requirements, stricter penalties** on transmission provider interconnection process performance.
- **Interconnection process automation** to respond to larger volumes of interconnection requests.
- **Improve current rules** for interconnection services associated with **generator replacement**.
- Develop **fast-track options** for **energy-only interconnection**.

Queue Management and Cost Allocation

Suggested Reforms:

- **First-ready first-served cluster studies** and **deadlines** for DERs
- **Automated** or **pre-approved** interconnection studies based on known components and automated data collection
- **Fast-Track Processing** based on **Pre-Screening Criteria**
- Allow **Flexible Interconnection** Strategies:
  - Last-in-first-out
  - Pro-rata
  - Competitive bidding
  - Emissions-based priority

Queue Management and Cost Allocation

Cost Allocation | Bulk Electric System

Varied feedback on whether **participant funding** should be **kept**, **reformed**, or **eliminated**

Alternative Strategies Discussed:

- Energy-only interconnection
- Proactive transmission planning
- Reduce barriers to non-utility transmission investment
- Delink individual generators from network upgrades

Queue Management and Cost Allocation

Cost Allocation | Distributed Energy Resources

Concerns that **increase in utility costs** would be **passed to ratepayers.**

Alternative Strategies Discussed:

- Group study
- Cost causer post-updated
- Preemptive upgrade
- Utility prorated
- Upgrade Fund

Queue Management and Cost Allocation

Cross-Cutting Insights

Improvements to queue backlogs and more fair and equitable allocation of costs can be improved via **enhanced coordination between interconnection and grid planning processes**, particularly transmission planning.

i2X Solution e-Xchange Topic Areas

Grid Engineering Practices & Standards

Queue Management & Cost Allocation

Managing big power sources connecting to long-distance lines, sharing big upgrade costs.

Grid Engineering Practices & Standards

Designing distant power lines, keeping big grid stable and reliable.

Data Transparency

Sharing grid status and issues for stable electricity movement.

Equity and Energy Justice

Considering fairness for all in energy choices and access, across both transmission and distribution.

Grid Engineering Practices & Standards

Engineering and technology focus

How can proposed solutions be executed?

Interconnection Workforce and Training

Preparing skilled people for connecting energy, spanning both transmission and distribution areas.

Queue Management & Cost Allocation

Handling small energy sources joining local lines, dividing costs for nearby upgrades.

Grid Engineering Practices & Standards

Creating local networks, ensuring safe delivery to homes and businesses.

Data Transparency

Giving real-time data to consumers for wise energy use.

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Grid Engineering Practices and Standards

Bulk Electric System

Highlighted importance of **improved hosting capacity mapping** and **clear definitions** of **transmission, sub-transmission,** and **distribution systems.**

Concerns included:

- Lack of data availability and integration
- Lack of engineering resources
- Data confidentiality and CEII concerns
- Lack of uniform requirements
- Concerns of effectiveness of hosting capacity maps

Grid Engineering Practices and Standards

Distributed Energy Resources

Higher penetration of DERs on the distribution grid, especially inverter-based DERs, is **challenging historical methods of system protection**, and requires consideration of **innovative approaches**.

Concerns included:

- Distance relay protection for IBRs
- Direct transfer trip (DTT) expense vs. protections
- Inconsistent adoption of IEEE 1547-2018

Grid Engineering Practices and Standards

Cross Cutting Insights

Lack of clear alignment on the definitions of **distribution**, **sub-transmission**, and **transmission**.

i2X Solution e-Xchange Topic Areas

Data Transparency

Queue Management & Cost Allocation

Managing big power sources connecting to long-distance lines, sharing big upgrade costs.

Grid Engineering Practices & Standards

Designing distant power lines, keeping big grid stable and reliable.

Data Transparency

Sharing current information on grid capacity and projects in the queue.

Equity and Energy Justice

Considering fairness for all in energy choices and access, across both transmission and distribution.

Data Transparency

Multidisciplinary

What transparency concerns must be addressed?

Interconnection Workforce and Training

Preparing skilled people for connecting energy, spanning both transmission and distribution areas.

Queue Management & Cost Allocation

Handling small energy sources joining local lines, dividing costs for nearby upgrades.

Grid Engineering Practices & Standards

Creating local networks, ensuring safe delivery to homes and businesses.

Data Transparency

Enabling cost-effective outcomes with grid hosting capacity and upgrade information.

Grid Data Transparency

Solutions e-Xchangers ranked importance of improvement measures to increase pre-application data transparency:

1. Technological/software constraints
1. High cost of adequate and timely data
2. Labor and workforce
3. Confidentiality of CEII
4. Tariff Compliance
4. Is information transparency the solution?

Grid Data Transparency

Call for centralized entities to track important metrics:

- Number and capacity of interconnection requests in a given queue
- Time to complete studies
- Time from submission of interconnection request to commercial operation
- Interconnection costs by fuel type
- Withdrawal rates
- Frequency of triggered upgrades
- Locational and spatial trends
- Labor hours required to complete interconnection studies
- Number of studies completed by study phase

i2X Solution e-Xchange Topic Areas

Interconnection Workforce and Training

Queue Management & Cost Allocation

Managing big power sources connecting to long-distance lines, sharing big upgrade costs.

Grid Engineering Practices & Standards

Designing distant power lines, keeping big grid stable and reliable.

Data Transparency

Sharing grid status and issues for stable electricity movement.

Equity and Energy Justice

Considering fairness for all in energy choices and access,

Interconnection Workforce & Training

Multidisciplinary

How to train experts for secure energy connections?

Queue Management & Cost Allocation

Handling small energy sources joining local lines, dividing costs for nearby upgrades.

Grid Engineering Practices & Standards

Creating local networks, ensuring safe delivery to homes and businesses.

Data Transparency

Giving real-time data to consumers for wise energy use.

Interconnection Workforce and Training

Preparing skilled people for connecting energy, spanning both transmission and distribution areas.

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Interconnection Workforce and Training

Challenges **hiring and retaining** qualified interconnection staff:

- Industry competition and shortage of qualified engineers
- Complex skills requirements, repetitive work
- Lack of training and education opportunities
- Low pay, inability to offer competitive salaries and benefits, flexibility, culture

Interconnection Workforce and Training

Proposed Solutions:

- Automate where possible, look to emerging technologies
- Invest in training, education, and outreach

i2X Solution e-Xchange Topic Areas

Equity and Energy Justice

Queue Management & Cost Allocation

Managing big power sources connecting to long-distance lines, sharing big upgrade costs.

Grid Engineering Practices & Standards

Designing distant power lines, keeping big grid stable and reliable.

Data Transparency

Sharing grid status and issues for stable electricity movement.

Equity and Energy Justice

Considering fairness for all in energy choices and access, across both transmission and distribution.

Equity & Energy Justice

Multidisciplinary

Who is impacted by and benefits from proposed solutions?

Interconnection Workforce and Training

Preparing skilled people for connecting energy, spanning both transmission and distribution areas.

Queue Management & Cost Allocation

Handling small energy sources joining local lines, dividing costs for nearby upgrades.

Grid Engineering Practices & Standards

Creating local networks, ensuring safe delivery to homes and businesses.

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Equity and Energy Justice

The long timelines, high costs, complexity, and uncertainty of the interconnection process **disproportionately impact developers serving disadvantaged communities**, who generally have **limited resources and capacity**.

Limited access **prevents communities from accessing cost savings**, **public health**, **resilience**, and **climate benefits** of renewable generation and storage.

Equity and Energy Justice

Recommendations:

- Incorporate EEJ community identification and socioeconomic vulnerability layers into interconnection hosting capacity mapping
- Technical assistance and education opportunities
- Improved grid data transparency and information accessibility
- Independent engineering and dispute resolution service
- Address disproportionately high cost of interconnection
- Regulatory relief to mitigate queue delays
- Center equity goals in planning and valuation efforts
- Incentivize and enable community and tribal ownership

Cross-Cutting Lessons and Top-Line Takeaways

Stakeholders agree,

Queues are **overloaded** and **growing**, and study **timelines are too long**; interconnection **costs are too high**, and **cost uncertainty** contributes to other challenges.

Cross-Cutting Lessons and Top-Line Takeaways

Speculative applications in the queue contribute to queue bloat and lengthy backlogs. However, developers submit them due to lack of ability to learn critical data in any other way.

Cross-Cutting Lessons and Top-Line Takeaways

Timely **hosting capacity information** and other **data transparency** measures is needed. Real-time data and uncertainty around **security issues** (CEII) have been limiting factors in improving transparency.

Cross-Cutting Lessons and Top-Line Takeaways

Cost allocation is a complex issue.

Cost-causer method leads to **high costs**, but **avoids passing costs onto utility ratepayers**.

Cross-Cutting Lessons and Top-Line Takeaways

New technologies and innovations provide promise, but challenge of implementation requires training and guidance to maintain grid safety and reliability.

Cross-Cutting Lessons and Top-Line Takeaways

Overburdened, limited interconnection workforce across the board. Salaries, benefits, training, outreach, and tedium of tasks and high workload pose significant barriers.

Cross-Cutting Lessons and Top-Line Takeaways

Improving equity of the interconnection process is **critical**. Data transparency, technical assistance, and regulatory reforms all tied to equity.

Cross-Cutting Lessons and Top-Line Takeaways

Solutions e-Xchanges brought together all types of energy system stakeholders to **work together towards a common goal**. Developers, distribution utilities, transmission grid operators, regulators, consultants, researchers and more support continued collaboration **to address the urgent and complex challenges of interconnection**.

1. Welcome & Opening Remarks
2. FERC Order 2023 Highlights
3. i2X Solution e-Xchanges Takeaways
4. Roadmap Overview & Solution Concept Interactive Exercise
5. Closing & Networking

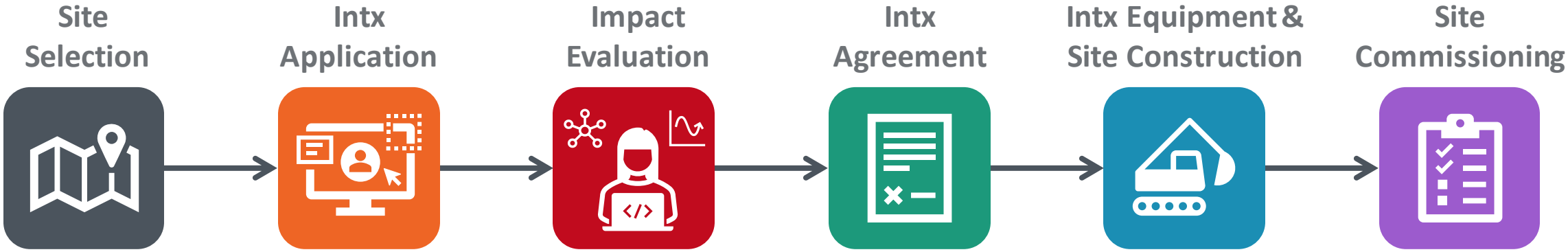
Presenter

Ammar Qusaibaty

Technology Advisor

Solar Energy Technologies Office

Solution options are many …



Site Selection	Intx Application	Impact Evaluation	Intx Agreement	Intx Equipment & Site Construction	Site Commissioning
Hosting Capacity Development & Validation Processes	Queue Application Processing Strategies	Engineering Resource Management & Study Process Strategies	Study & Upgrade Cost Transparency Practices	Construction Queue Management	Commissioning Staff Resource Availability
Grid Capacity Analysis & Transparency Requirements	Queue Management & Application Requirements	Standardized Evaluation Screening Criteria	Cost Allocation Methods for Capacity Upgrades	Third-Party Utility Equipment Installer Options	Standardized Commissioning Requirements
Hosting Capacity Analysis Methods & Tools	Application Intake Tools & Automation	Advanced Modeling & Automated Impact Evaluation Tools	Dynamic Controls & Operational Profiles	Non-Wire Alternative Technologies	Virtual & Off-Site Commissioning Tools

Technology & Engineering Administrative Processes Markets and Regulation

Interconnection is a dynamic and ever-changing landscape of challenges and solutions. Shaped by many, it demands careful coordination, communication, and collaboration.

Navigate with a roadmap to discover new pathways and solutions

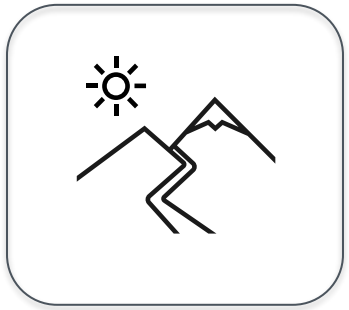
The next terawatts of generator interconnections*

paving ways to a reliable decarbonized U.S. electricity system by 2035

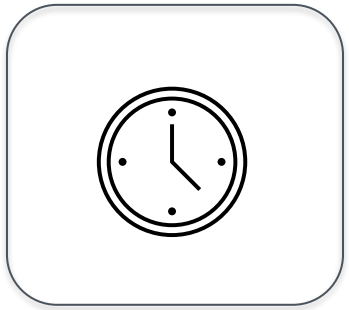
Statement of purpose: *To serve as a practical guide of key actions regulators, interconnection service providers, interconnection customers, and other stakeholders may take, within the next five years and beyond, to implement solutions to interconnection challenges that deliver a reliable decarbonized U.S. electricity system by 2035, efficiently, cost-effectively, equitably, and collaboratively.*

* This is an illustrative title only

A mountain climbing metaphor

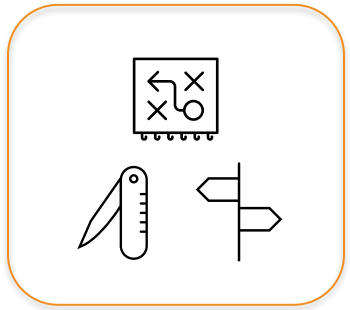


Target Destination



Timeframe

Trekkers



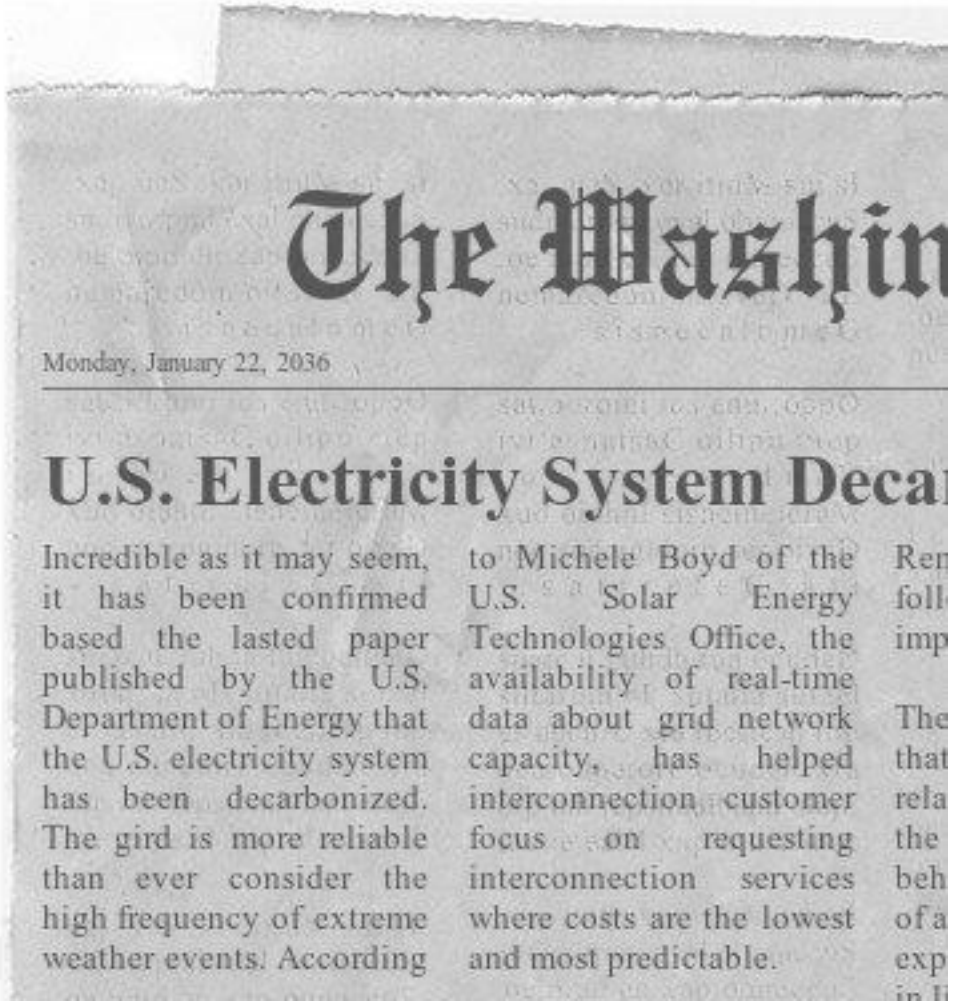
Things to do

Trackers

Target Destination in 2035

Interconnection services in years leading up to 2035 exhibit the following key qualities:

- **Transparent** availability and demand for services
- **Inclusive**, efficient, predictable, and collaborative procedures
- **Economically efficient** with equitable cost-benefit distributions
- Grid **Reliability-centered** excellence



The Washin

Monday, January 22, 2036

U.S. Electricity System Deca

Incredible as it may seem, it has been confirmed based the lasted paper published by the U.S. Department of Energy that the U.S. electricity system has been decarbonized. The gird is more reliable than ever consider the high frequency of extreme weather events. According to Michele Boyd of the U.S. Solar Energy Technologies Office, the availability of real-time data about grid network capacity, has helped interconnection customer focus on requesting interconnection services where costs are the lowest and most predictable.

Target Destination in 2035

Examples to describe qualities with measurable variables (KPIs) and success values

- **Transparent** availability and demand for services
  - Grid hosting capacity availability: real-time
  - IX grid upgrade costs estimates accuracy: 90%
- **Inclusive**, efficient, predictable, and collaborative procedures
  - Time from IX request to agreement: less than 4-months
  - Withdrawal rates of IX service requests: less than 15%
- **Economically efficient** with equitable cost-benefit distribution
  - Grid upgrades IX generators: not exceeding $0.05/W
- Grid **Reliability** ensuring excellence
  - Reliability of generators interconnected post-2027: "Five Nines" (99.999% uptime)

KPI = Key Performance Indicators

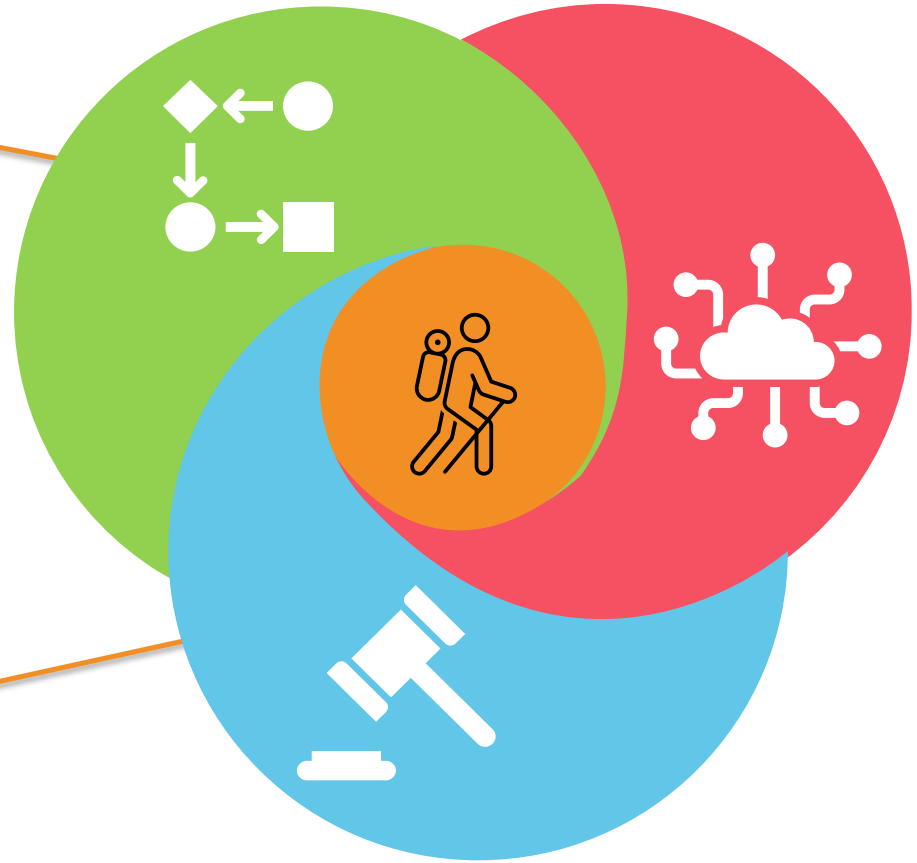
Tracker(s): a positioning system to track progress

To stay on a path towards the target destination, stakeholders collaboratively track and share data, measuring key performance indicators (KPIs) over time to quantitatively assess how close the current values are approaching success values for:

- Transparency
- Process efficiency
- Economic efficiency
- Grid reliably

Diverse stakeholders with interdisciplinary expertise

Energy regulatory authorities
Interconnection service providers
Interconnection Customers
OEM / Service/ Solution Providers
Local, State & Tribal Govs
Advocacy groups
Public-benefit organization
Research community
Other



“Things to do”: Roadmap actions satisfy four requirements

1. Increase Data Access & Transparency
   - (Grid Capacity. Costs. Timelines)
2. Improve Process and Timing
   - (Workforce. Queue Management. Interconnection Studies. Affected Systems Studies)
3. Promote Economic Efficiency
   - (Cost Allocation. Grid Planning Coordination)
4. Maintain Grid Reliability
   - (Generator Models. Modeling. Standards)

Action-Impact year. Short-term: 1-3 year. Medium-term: 1-5 year. Long-term 1-7 year

1. Increase Data Access and Transparency

Short-term

- Improve the scope, accessibility, quality, and standardization of current interconnection queue data, including project attributes and cost estimates

Medium-term

- Enhance the scope, timeliness, accuracy of interconnection study models and data that are made available to interconnection customers

2. Improve Process and Timing (Queue Management)

Short-term

- Develop more stringent commercial readiness requirements and financial commitments that balance effectiveness and open access principles, in compliance with FERC Order 2023
- Automate more parts of the interconnection process, such as data input and validation, some customer communications, data sharing across processes and models, and data analysis and visualization (ongoing)

Medium-term

- Create new and expand and better utilize existing fast-track options for generator interconnection, including surplus interconnection service, generation replacement service, and energy-only interconnection service

Long-term

- Explore options to allow developers to self-fund and provide their own interconnection studies, subject to transmission provider rules and requirements

2. Improve Process and Timing (Workforce)

Short-term

- Upskill the existing workforce through continuing education programs
- Consider improvements compensation and benefits to retain interconnection staff

Medium-term

- Expand number of talents in the interconnection workforce via outreach, career counseling, and curriculum development in higher education (medium-term)

3. Promote Economic Efficiency

Short-term

- Explore options for identifying and allocating the costs of proactive transmission investments, including different options for state and federal government and generator funding

Medium-term

- Ensure that generators have the option to connect to the transmission system without paying for congestion-related upgrades under energy-only interconnection service

Long-term

- Explore and evaluate potential options for decouple interconnection and network upgrades

4. Maintain a Reliable Grid

Short-term

- Require collection of EMT models for all IBRs during interconnection process, ahead of EMT studies being needed and beyond FERC Order 2023 rules
- Develop screening criteria to determine when EMT studies are necessary within a region
- Develop study process flow that is better aligned with generation project development timelines

Interactive Exercise Overview

- Two conceptual solutions to discuss. Feel empowered to put solutions together.
- One exercise for Transmission (data transparency)
- One exercise for Distribution (Automation)
- In each table, for each role there must be at least one representative:
  1. Energy regulatory authorities
  2. Interconnection service providers
  3. Interconnection Customers
  4. OEM / Service/ Solution Providers
  5. Advocacy groups Public-benefit organization
  6. Research community
  7. Other (e.g., Local, State & Tribal Govs)
- Read the case, work on the questions as a group.
- Recommend to spend 5, 5, 10, 25 min for Questions 1, 2, 3, and 4 respectively
- Have fun and use your creativity, your experience or lack of experience.

BPS Exercise

Bulk Power System | Transparency and Grid Data Access | Heatmap+

Problem Statement

The current generator interconnection procedures in the U.S. transmission system require interconnection customers to have access to data on grid network conditions/congestion, status of current interconnection queues, and locational network models. However, these data are often not easily accessible or not transparent enough, so interconnection customers often use interconnection service requests to explore business development opportunities. This leads to high volumes of exploratory requests, high request withdrawal rates, interconnection impact restudy loops, and interconnection processing delays.

Federal Energy Regulatory Commission (FERC) order 2023 requires all transmission providers to offer publicly accessible information about grid network hosting capacity referred to as heatmaps. These heatmaps provide grid data details about the provider's transmission system and updated regularly based on the most accurate and latest grid model, interconnections studies, and executed interconnection agreements.

Heatmap+ Solution Concept

Heatmap+ builds on FERC order 2023. It's a grid data visualization portal and an interconnection study studio. It helps interconnection customers make more informed decisions about developing new generation. Heatmap+ offers tiered features, starting with a freemium service accessible to any user to a fee-based premium subscription for verified customers cleared to access critical energy electric infrastructure information. Heatmap+ may offer the following features:

Freemium Service

Query Capabilities: Users can access Heatmap+ to pose basic inquiries regarding potential generators, evaluating safety, stability, and estimated network upgrade costs for a limited number of interconnection points.

Identify High-Interest Areas: Users can find areas with significant interconnection demand, including pending requests from anonymous interconnection customers.

Track Network Upgrades: Users can view the latest network upgrades and their associated costs, aiding in informed decision-making about site selections.

Premium Service (+Freemium)

Advanced Modeling Studio: Premium users can upload generator models and utilize the Heatmap+ modeling studio, incorporating stability, power flow, and short circuit analyses under various scenarios seamlessly through an API, eliminating the need for complex downloads.

Collaboration Features: Premium users can engage in messaging and collaboration, connecting with potential partners for joint projects and interconnection point sharing.

Benefits to transmission providers

Heatmap+ can provide transmission providers with rich user data and advanced analytics to support grid planning and interconnection studies. This data and analytics can be used to identify underutilized or congested areas of the grid, signal to potential interconnection customers areas of interest, assess the impact of new generation on the grid, optimize the placement of new generation, plan for future grid upgrades, automate the interconnection process.

Timeline: 3-5 years from implementation to full use and impact.

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Bulk Power System | Transparency and Grid Data Access | Heatmap+

Interactive Discussion Questions

1. To what extent does this solution concept address the stated problem?
2. What features you recommend adding or removing? And how would such features improve other goals of the interconnection process (e.g., equitable distribution of costs for shared grid benefits)
3. How practical is this solution concept (adding or removing features) within a 3–5-year timeframe?
4. Consider the different actors needed to collaborate to implement this solution and their interdisciplinary expertise, describe actions needed to implement this solution and potential obstacles/ barriers/ gaps you foresee in each area. Please specify any other actors, if needed.

Actors & Actions

Actor/Expertise	Engineering & Technology	Market & Regulatory	Administrative & Change Management
FERC (Regulator)			
Transmission Provider			
Project Developer (Interconnection Customer)			
OEM / Service/ Solution Provider			
Public-benefit Organization			
Research Community (e.g., National Labs)			
Other			

Actors & Barriers

Actor/Expertise	Engineering & Technology	Market & Regulatory	Administrative & Change Management
FERC (Regulator)			
Transmission Provider			
Project Developer (Interconnection Customer)			
OEM / Service/ Solution Provider			
Public-benefit Organization			
Research Community (e.g., National Labs)			
Other			

DER Exercise

Distribution Power System(s) | Interconnection Process and Timing | Automation

Problem Statement

The electric power distribution sector is witnessing a surge in generator interconnection service requests, accompanied by larger generator scales (ranging from 50 kW to 5 MW) and increased engineering complexity, such as solar photovoltaics (PV) with battery storage, hybrids, and distributed wind systems. This heightened demand is driven by low costs of clean energy technologies, federal tax incentives (e.g., IRA), and state and local policies supporting decarbonization and energy equity. Current solutions that streamline the interconnection process, including software-based workflow automation (e.g., PowerClerk, GridUnity) and integrated grid modeling solutions, primarily target smaller residential-scale systems (< 50 kW). To meet the escalating demand efficiently, cost-effectively, and promptly, there is a pressing need to expand these solutions to encompass larger commercial, industrial, and community-scale generators.

Automation Solution Concept

An automation solution concept, named "iGridConnect 30," leverages existing workflow automation and grid modeling software solutions to enhance the efficiency of both interconnection customers and service providers. This digital enterprise solution is designed to manage and conduct studies, while delivering results for hundreds of interconnection requests in 30 days, specifically catering to commercial, industrial, and community-scale generators Features include:

Application intake & management integration features

Application Submission & Status Tracking: Interconnection customers submit interconnection requests through the platform, automatically entering them into a queue for review. The system validates inputs and submits models, while providing automated status updates on progress.

Automated Pre-Screening: The platform conducts initial compatibility assessments, filtering out applications that clearly meet, exceed, or fail basic criteria to focus utility staff on complex and unique projects, with the option to prioritize those that are most ready for construction.

Priority Assignment: The system automatically assigns priorities based on factors like project size, technology type, and regulatory deadlines, which can ensure efficient processing.

Interconnection studies features

Automated Feasibility Analysis: Utilizing automated modeling tools, the system conducts preliminary feasibility studies, considering factors like limitations on grid capacity, maintaining good power quality, and ensuring safety and reliability.

Automated impact Analysis: The system conducts automated analyses aligned with technical standards and utility best practices (e.g., voltage, short circuit, anti-islanding analyses) The system provides utility staff with engineering diagnostics and options to resolve them cost-effectively.

Scenario Modeling and Queue optimization: Utility engineering staff can employ automated scenario modeling to assess various interconnection scenarios based on customer preferences, optimizing generator location, design, and operating features. Additionally, the system could group study requests to reduce costs, enhance reliability, and expedite the interconnection queue.

Affected systems coordinated studies: Where and when applicable, the system interfaces with the internal interconnection study systems of other grid network operators (e.g., transmission owners or providers) to share interconnection request data and grid models. This facilitates seamless and timely study of affected systems and grid impacts.

Timeline: 3-5 years from implementation to full use and impact.

Distribution Power System(s) | Interconnection Process and Timing | Automation

Interactive Discussion Questions

1. To what extent does this solution concept address the stated problem?
2. What features do you recommend adding or removing? And how would such features improve other goals of the interconnection process (e.g., equitable distribution of costs for shared grid benefits)
3. How practical is this solution concept (adding or removing features) within a 3–5-year timeframe?
4. Consider the different actors needed to collaborate to implement this solution and their interdisciplinary expertise, describe actions need to implement this solution and potential obstacles/ barriers/ gaps you foresee in each area. Please specify any other actors, if needed.

Actors & Actions

Actor/Expertise	Engineering & Technology	Market & Regulatory	Administrative & Change Management
State Energy Commission (Regulator)			
Distribution Utility (Interconnection Provider)			
Project Developer (Interconnection Customer)			
OEM / Service/ Solution Provider			
Public-benefit Organization			
Research Community (e.g., National Labs)			
Other			

Actors & Barriers

Actor/Expertise	Engineering & Technology	Market & Regulatory	Administrative & Change Management
State Energy Commission (Regulator)			
Distribution Utility (Interconnection Provider)			
Project Developer (Interconnection Customer)			
OEM / Service/ Solution Provider			
Public-benefit Organization			
Research Community (e.g., National Labs)			
Other			

i2X Code of Conduct

- Assume good faith and respect differences.
- Listen actively and respectfully.
- Use "Yes and" to build on others' ideas.
- Please self-edit and encourage others to speak-up.
- Seek to learn from others.

Join . Engage . Collaborate

Interactive Exercise

Website: energy.gov/i2X
Email: i2x@ee.doe.gov

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Activity Notes

Notes synthesizing keys points, insights and themes from the interactive activity can be found here: Box Link

i2X Technical Assistance Projects

- **Purpose:** To work on practical technical interconnection challenges that U.S.-based organizations are facing in the distribution grids or bulk power grid
- **Scope:** Solar, wind, energy storage or hybrid integration of these technologies
- **Lab Partners:** Sandia National Labs (SNL), Pacific Northwest National Labs (PNNL) and the National Renewable Energy Lab (NREL)
- **Partners:** 12 lead organizations to collaborate with i2X lab partners.
- **Project Timeline:** Projects are scheduled to begin immediately and run until March 2024.

Technical Assistance Themes

- **Flexible Interconnection**
  - Financial Impacts of Curtailment
  - PCS Impacts on XFRMs
  - Flex IX modeling
- **Direct Transfer Trip (DTT)**
  - Alternatives to DTT
  - Guidance on anti-islanding mechanisms
- **Hosting Capacity Analysis (HCA)**
  - HCA Screening methods
  - Technology Inclusive HCA
- **Interconnection Process Standardization**
  - Pre-screening methods
  - Interconnection study automation
  - Procedures for detailed technical screens

Join . Engage . Collaborate

Solution e-Xchanges Second Season

Website: energy.gov/i2X
Email: i2x@ee.doe.gov

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Join . Engage . Collaborate

Networking

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